Nonresidential Space and Water Heating Proposal

California Statewide Utility Codes and Standards Program

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ACM Update-Water & Space Heating

- Summary of current code requirements and typical practice
- Summary of code change proposals

Water & Spacing Heating

Summary of code change proposals

- Central DHW System Performance Algorithms
  - Recirculation system heat loss – control, plumbing design, & branch
  - Can be used for hydronic distribution systems
- ACM Standard Designs
  - Heating equipment efficiency
    - Res ACM: Wall-furnace standard design – no change
    - Nonres ACM: Space heating boiler – hot water boiler, not steam boiler
  - Air duct in MF building – standard design same as proposed (no credit)
- Pipe Insulation
  - Update mandatory insulation thickness - Table 123–a
  - Cover pipes in unconditioned buildings

Water & Spacing Heating

Current Code Requirements

- DHW Performance Algorithms
  - Control technology savings – not adequate
  - No consideration in distribution loop designs
- ACM Standard Designs
  - Res ACM: wall furnace – standard design same as proposed design
  - Nonres ACM: steam boils are assumed in standard designs
  - MF building air duct distribution – same as SF buildings
- Pipe Insulation
  - Table 123-a update
  - Not required in unconditioned buildings (Table 100)
- Hydronic Space Heating Algorithms (no change)
  - Pipe heat loss in unconditioned space included
  - Pipe heat loss in conditioned space not considered

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Typical Practice

- MF DHW System
  - Central DHW distribution with recirculation loop
  - Control technologies are proven to save energy
  - Recirculation loops are designed/installed without consideration of efficiency
- Standard designs
  - Fan type wall furnace is more efficient the gravity type
  - Hot water boilers are usually used for hydronic heating
  - Air ducts are in conditioned spaces in most MF buildings
- Pipe Insulation
  - Cost effectiveness is the barrier for more insulation

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DHW ACM – Proposal Overview

- Recirculation Loop Pipe Heat Loss
  - Recirculation loop configurations
  - Flow and temperature dependent
  - Recirculation system controls
- Standard and Proposed Recirculation Design
  - Details to be provided by the MF DHW CASE
    - Standard design: based on a PIER study on MF DHW system
    - User input ≠ proposed design, minimum recirculation loop surface area is defined
- Branch Pipe Heat Loss

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DHW ACM – Hourly Heating Load

Residential ACM Appendix E

Equation RE-1 $$HARL_k = HSEU_k \times DLM_k \times SSM_k + HRDL_k + \sum_l HJL$$

- Hourly Adjusted Recovery Load
- Hourly Standard End Use
- Distribution Loss Multiplier
- Solar Savings Multiplier
- Hourly Recirculation Distri. Loss
- Hourly Jacket Loss

Implement monthly variation

Inside dwelling unit:

$DLM_k = 1 + (SDLM_k - 1) * DSM_k$

$DSM_k = 1$ for MF

SSM_k should be applied to $HRDL_k$ as well; however, it depends on how SSF is rated

Proposed Improvement

- Recirculation Loop
  - Plumbing layout based on building geometry
  - Control schedule
  - HW Draw patterns
- Branch
  - Pipe heat loss
  - Water waste – energy loss

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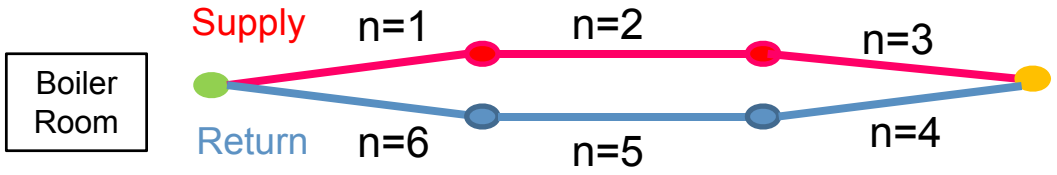
DHW ACM – Recirc. Loop Heat Loss

- Treatment of recirculation configuration



- Pipe heat loss: Two heat loss modes

$$HRDL_k = \sum_n UA_n \cdot (T_{avg,n} - T_{amb,n})$$

Steady-flow mode $$T_{avg,flow} = (T_{in} - T_{amb}) \cdot \left(\frac{1 - e^{-\frac{UA}{\rho c_p V}}}{\frac{UA}{\rho c_p V}}\right) + T_{amb}$$

Cool down mode $$T_{avg,cool} = (T_{avg,flow} - T_{amb}) \cdot e^{-\frac{UA}{mc_p} \cdot t} + T_{amb}$$

- Hourly control schedule

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DHW ACM – Hourly Control Schedule

- Continuous pumping

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Pump off time (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_{supply} (^oF)	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135

- Demand Control (t determined by hot water return pipe configuration)

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Pump off time (min)	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t
T_{supply} (^oF)	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135

- Temperature Modulation

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Pump off time (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_{supply} (^oF)	125	125	125	125	130	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	130

- Continuous monitoring: reduce supply temperature by 5^{o}F

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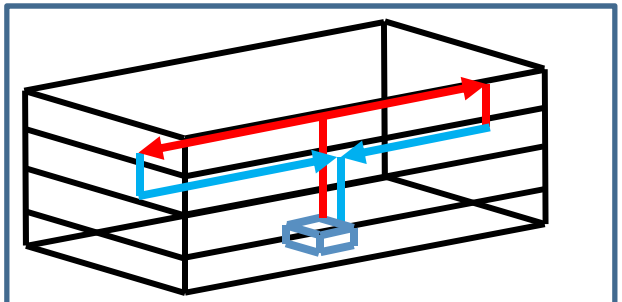
DHW ACM – Recirc. Designs

- Standard design - dual loop
  - Boiler room near the middle of the building
  - Smaller pipe diameters → less surface area
- Proposed design options
  - Same as standard design – need verification
  - ACM Default design: one loop
  - User input: compared to /adjusted by the default design
- Verification
  - Res: HERS
  - NR: follow Appendix NA2

Standard Design



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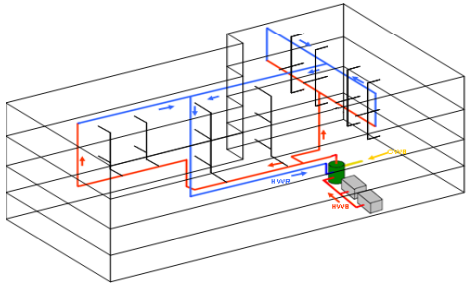
DHW ACM – Proposed Recirc. Design

User Inputs



4 stories / 2 loops

Supply Recirculation Pipe

Section #1	Section #2	Section #3
10	30	
Unconditioned Space 2”	Conditioned Space 2”	

Return Recirculation Pipe

Section #1	Section #2	Section #3
30	10	
Conditioned Space 1”	Unconditioned Space 3/4”	

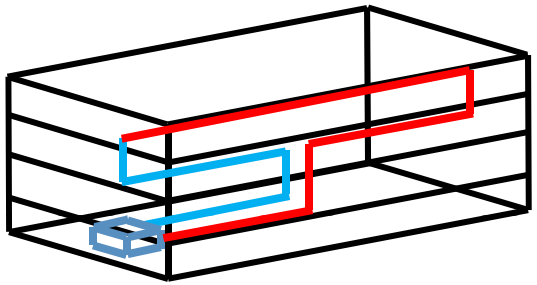
Generate ACM Default

Pipe surface area < Default?

No — Keep user input

Yes — Pipe surface area adjustment factor

Default Design



	Supply	Return
Loop 1	80 ft	80 ft
Loop 2	80 ft	80 ft
Total	320 ft	

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Air Ducts – Current Standard Design (Res)

- Table R3-30 – Summary of Standard Design HVAC System

Propose Design		Standard Design		
Heating	**Cooling**	**Heating**	**Cooling**	**Detailed Specifications**
Through-the-wall heat pump		Same equipment as proposed design with no air distribution ducts		Equipment efficiency determined by CEC Appliance Efficiency Regulations
Gas wall furnace with or without ducts and/or circulation fan	Any	Same equipment as proposed design with no air distribution ducts	Same equipment as proposed design with no air distribution ducts	
Any other electric heat including electric resistance, water source heat pump, etc.	Any	Split system heat pump with air distribution ducts**:** **For multi-family buildings, air distribution duct configurations are the same as those in the proposed design.**		SEER per Package D Verified refrigerant charge (prescriptive requirement) No credit for sizing No credit for cooling coil airflow No credit for reduced fan power
All other gas heating	Any	Split system air conditioner with gas furnace and air distribution ducts. **For multi-family buildings, air distribution duct configurations are the same as those in the proposed design.**		
Note: The standard design cooling system is also used for the proposed design if the proposed design has no air conditioning				

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Air Ducts – Proposed Code Language (Res)

- Update Table R3-30 in Res ACM

This table is applicable only when the standard design system has air distribution ducts as determined in Table R3-30. **For multi-family buildings, air distribution duct configurations are the same as those in the proposed design.**

Configuration of the Proposed Design	Standards Design	
	Standard Design Duct Location	**Detailed Specifications**
Attic over the dwelling unit	Ducts and air handler located in the attic	Ducts sealed (prescriptive requirement) No credit for reduced duct area No credit for increased duct R-value or buried ducts No credit for low-leakage air handler
No attic but crawlspace or basement	Ducts and air handler located in the crawlspace or basement	
No attic, crawlspace or basement	Ducts and air handler located indoors	

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Air Ducts – Current Standard Design (NR)

- Hydronic heating system with no cooling (coastal CZs)
  - The "Other" category compared to ducted systems

Table N2-13 – Standard Design HVAC System Selection

Building Type	System Type	Proposed Design Heating Source	System
Low-Rise Nonresidential (three or fewer stories above grade)	Single Zone	Fossil	System 1 – Packaged Single Zone, Gas/Electric
		Electric	System 2 – Packaged Single Zone, Heat Pump
	Multiple Zone	Any	System 3 – Packaged VAV, Gas Boiler with Reheat
High Rise Nonresidential (four or more stories)	Single Zone	Any	System 5 – Built-up Single Zone System with Central Plant
	Multiple Zone	Any	System 4 – Central VAV, Gas Boiler with Reheat
All Residential including Hotel/Motel Guest Room	Hydronic	Any	System 5 – Four Pipe Fan Coil System with Central Plant
	Other	Fossil	System 1 (No economizer) – Packaged Single Zone, Gas/Electric
		Electric	System 2 (No economizer) – Packaged Single Zone, Heat Pump

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Air Ducts – Proposed Code Language (NR)

- Table N2-14 – System #1 and System #2 Descriptions

  Ducts: For ducts installed in unconditioned buffer spaces or outdoors as specified in § 144(k), the duct system efficiency shall be as described in Section 2.5.3.18. <u>For all residential including hotel/motel guest room, duct configurations shall be the same as proposed.</u>

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Boiler – Current Standard Designs

- EnergyPro use steam boiler efficiency as standard design heating equipment
- Federal boiler efficiency standards (AFUE)

	Effective January 1, 1992	Effective Septemper 1, 2012
Gas steam boilers with single phase electrical supply	75%	80%
Gas hot water boilers with single phase electrical supply	80%	82%

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Boiler – Proposed Code Language

- Specify hot water boiler as the standard design heating equipment
- NR ACM
  - Table N2-15 – System #3 Description

  Heating System: Gas hot water boiler
  - Table N2-16 – System #4 Description

  Heating System: Gas hot water boiler
  - Table N2-17 – System #5 Description

  Heating System: Gas hot water boiler

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Wall Furnace – Current Standard Designs

- Res ACM: standard design is the same as proposed design
- Federal standards: fan based is more efficient

Type	Capacity (Btu per hour)	Minimum AFUE (%)
Fan	≤ 42,000	73
Fan	> 42,000	74
Gravity	≤ 10,000	59
Gravity	> 10,000 ≤ 12,000	60
Gravity	> 12,000 ≤ 15,000	61
Gravity	> 15,000 ≤ 19,000	62
Gravity	> 19,000 ≤ 27,000	63
Gravity	> 27,000 ≤ 46,000	64
Gravity	> 46,000	65

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Wall Furnace – Fan Type not Cost Effective

- Electric wiring cost not included

Climate Zone	PV Energy Savings ($/dwelling unit)	Incremental Wall Furnace Cost ($/dwelling unit)	LCC ($/dwelling unit)
1	$212	$514	$302
2	$227	$514	$287
3	$102	$514	$412
4	$120	$514	$394
5	$53	$514	$461
6	$9	$514	$505
7	$4	$514	$510
8	$17	$514	$497
9	$9	$514	$505
10	$44	$514	$470
11	$257	$514	$257
12	$241	$514	$273
13	$189	$514	$325
14	$254	$514	$260
15	$16	$514	$498
16	$576	$514	-$62

Water & Spacing Heating

Pipe Insulation – Current Requirements

- Not required for unconditioned building
- Considering increase all insulation thickness by ½ inch

TABLE 123-A PIPE INSULATION THICKNESS

FLUID TEMPERATURE RANGE (°F)	CONDUCTIVITY RANGE (in Btu-inch per hour per square foot per °F)	INSULATION MEAN RATING TEMPERATURE (°F)	NOMINAL PIPE DIAMETER (in inches)					
			Runouts up to 2	1 and less	1.25-2	2.50-4	5-6	8 and larger
			INSULATION THICKNESS REQUIRED (in inches)					
Space heating systems (steam, steam condensate and hot water)								
Above 350	0.32-0.34	250	1.5	2.5	2.5	3.0	3.5	3.5
251-350	0.29-0.31	200	1.5	2.0	2.5	2.5	3.5	3.5
201-250	0.27-0.30	150	1.0	1.5	1.5	2.0	2.0	3.5
141-200	0.25-0.29	125	0.5	1.5	1.5	1.5	1.5	1.5
105-140	0.24-0.28	100	0.5	1.0	1.0	1.0	1.5	1.5
Service water heating systems (recirculating sections, all piping in electric trace tape systems, and the first 8 feet of piping from the storage tank for nonrecirculating systems)								
Above 105	0.24-0.28	100	0.5	1.0	1.0	1.5	1.5	1.5
Space cooling systems (chilled water, refrigerant and brine)								
40-60	0.23-0.27	75	0.5	0.5	0.5	1.0	1.0	1.0
Below 40	0.23-0.27	75	1.0	1.0	1.5	1.5	1.5	1.5

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Pipe Insulation – Proposed Change

- DHW pipe in unconditioned buildings

TABLE 100-A APPLICATION OF STANDARDS

Occupancies	Application	Mandatory	Prescriptive	Performance	Additions/Alterations
General Provisions		100, 101, 102, 110, 111			
Nonresidential, High-Rise Residential, And Hotels/Motels	General	140	142	141	149
	Envelope (conditioned)	116, 117, 118	143		
	Envelope (unconditioned, process spaces)	-------	143(c)		
	HVAC (conditioned)	112, 115, 120-125	144		
	Water Heating (~~conditioned~~)	113, 123	145		
	Indoor Lighting (conditioned, process spaces)	119, 130, 131, 134	143(c), 146		
	Indoor Lighting (unconditioned)	119, 130, 131, 134	143(c), 146	N.A.	
	Outdoor Lighting	119, 130, 132, 134	147		

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Pipe Insulation – Proposed Change

- Increase MF DHW recirculation loop insulation

FLUID TEMPERATURE RANGE (°F)	CONDUCTIVITY RANGE (in Btu-inch per hour per square foot per °F)	INSULATION MEAN RATING TEMPERATURE (°F)	NOMINAL PIPE DIAMETER (in inches)					
			Runouts up to 2	1 and less	1.25 - 2	2.5-4	5 - 6	8 and larger
			INSULATION THICKNESS REQUIRED (in inches)					
Space heating systems **and processing** (steam, steam condensate and hot water)								
Above 350	0.32-0.34	250	1.5	2.5	2.5	3	3.5	3.5
251-350	0.29-0.31	200	1.5	2	2.5	2.5	3.5	3.5
201-250	0.27-0.30	150	1	1.5	1.5	2	2	3.5
141-200	0.25-0.29	125	0.5	1.5	1.5	1.5	1.5	1.5
105-140	0.24-0.28	100	0.5	1	1	1	1.5	1.5
Service water-heating systems (recirculating sections **and branch pipes connected to recirculation loops**, all piping in electric trace tape systems, and the first 8 feet of piping from the storage tank for nonrecirculating systems)								
Above 105	0.24-0.28	100	~~0.5~~1	~~1~~1.5	~~1~~1.5	~~1.5~~2	~~1.5~~2	~~1.5~~2
Space cooling systems (chilled water, refrigerant and brine)								
40-60	0.23-0.27	75	0.5	0.5	0.5	1	1	1
Below 40	0.23-0.27	75	1	1	1.5	1.5	1.5	1.5

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QUESTIONS & COMMENTS